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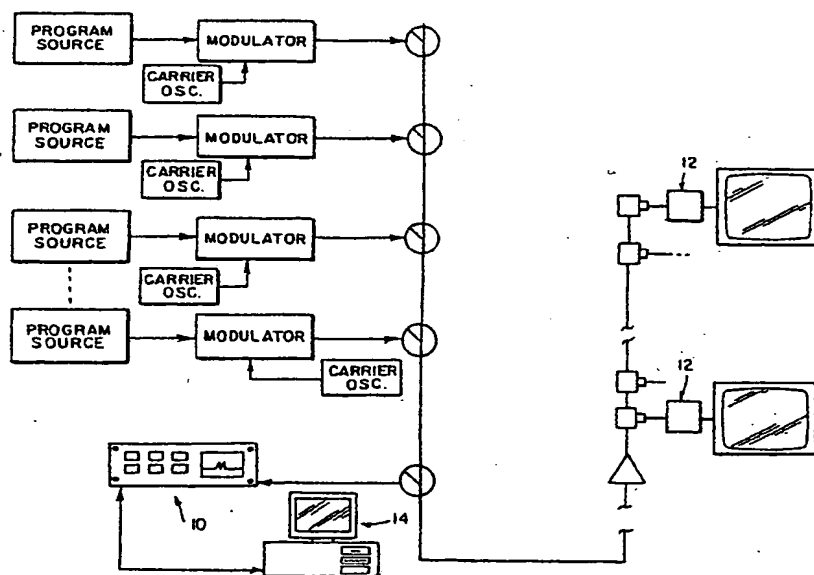— With international search report.

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(54) Title: METHOD AND APPARATUS FOR MONITORING INGRESS NOISE WITHIN AN OCCUPIED CHANNEL

(57) Abstract: A method (Fig. 1) and apparatus (10) for testing a communication network (Fig. 2) for ingress include the steps of, and an instrument (10) for, establishing a first signal level corresponding to presence of a communication signal on the network, determining a second, current signal level, comparing the second signal level to the first signal level, and if the second signal level does not bear a predetermined relationship to the first signal level, recording the second signal level.

METHOD AND APPARATUS FOR MONITORING INGRESS NOISE WITHIN AN OCCUPIED CHANNEL

Field of the Invention

This invention relates to the maintenance of networks. It is disclosed

5    in the context of a CATV system, but is believed to be useful in other applications as

well.

Background of the Invention

A significant challenge in maintenance in networks, such as the return

10    paths of CATV systems and the like, for the foreseeable future will be to monitor

ingress into communication channels, such as the CATV return bands, that are largely

occupied. Those few frequency bands that are empty will either be guard bands

between services, or frequency bands already known to contain consistently high

levels of noise ingress.

15    One presently known solution is to monitor primarily the guard bands

between services and to set alarm limits according to the monitored activity in these

guard bands. Since almost all troublesome ingress is broadband, the energy found in

the guard bands is generally felt to be a reliable indicator of the ingress that must be in

the occupied bandwidths as well. This approach works well, but it is believed that an

20    approach that makes full use of digital signal processing (DSP) techniques would be

superior to analog alternatives.

Disclosure of the Invention

According to an aspect of the invention, a method of testing a

25    communication network includes establishing a first signal level corresponding to

presence of a communication signal on the network, determining a second, current

signal level, comparing the second signal level to the first signal level, and if the

second signal level does not bear the predetermined relationship to the first signal

level, recording the second signal level.

30    Illustratively according to this aspect of this invention, the method

further includes repeating the steps of determining a second, current signal level,

comparing the second signal level to the first signal level, and if the second signal

level does not bear the predetermined relationship to the first signal level, recording the second signal level.

Further illustratively according to this aspect of the invention, the method further includes dividing a bandwidth of the network into an arbitrary number

5    of frequencies or ranges of frequencies, and repeating the steps of determining a second, current signal level, comparing the second signal level to the first signal level, and if the second signal level does not bear the predetermined relationship to the first signal level, recording the second signal level includes moving to another frequency or range of frequencies and repeating the steps of determining a second, current signal

10   level, comparing the second signal level to the first signal level, and if the second signal level does not bear the predetermined relationship to the first signal level, recording the second signal level.

Additionally illustratively according to this aspect of the invention, establishing a relationship includes establishing the same relationship for each

15   frequency or range of frequencies.

Illustratively according to this aspect of the invention, establishing a first signal level includes establishing a first signal level for each frequency or range of frequencies.

Further illustratively according to this aspect of the invention,

20   establishing a first signal level for each frequency or range of frequencies includes establishing the same first signal level for each frequency or range of frequencies

Additionally illustratively according to this aspect of the invention, dividing a bandwidth of the network into multiple frequencies or ranges of frequencies and determining the second signal level together include fast Fourier

25   transforming the second signal.

Further illustratively according to this aspect of the invention, the method includes providing a graphical representation of the recorded second signal levels.

According to another aspect of the invention, an instrument for testing

30   a communication network for ingress is adapted for coupling to the network. The instrument permits the establishment of a first signal level corresponding to presence of a communication signal on the network, determining a second, current signal level

on the network, and comparing the second signal level to the first signal level. The instrument is further adapted for determining if the second signal level bears a predetermined relationship to the first signal level, and, if the second signal level does not bear the predetermined relationship to the first signal level, recording the second

5    signal level.

Illustratively according to this aspect of the invention, the instrument is adapted for dividing the bandwidth of the network into an arbitrary number of frequencies or ranges of frequencies. The instrument permits the establishment of a first signal level in each frequency or range of frequencies corresponding to the

10   presence of a communication signal in that frequency or range of frequencies. The instrument is further adapted for then moving to another frequency or range of frequencies, determining the second signal level in that , and comparing the second signal level in that frequency or range of frequencies to the first signal level for that frequency or range of frequencies. The instrument is further adapted for determining

15   if the second signal level in that frequency or range of frequencies bears a predetermined relationship to the first signal level for that frequency or range of frequencies, and, if the second signal level for that frequency or range of frequencies does not bear the predetermined relationship to the first signal level for that frequency or range of frequencies, recording the second signal level for that frequency or range

20   of frequencies.

Further illustratively according to this aspect of the invention, the instrument is adapted for determining if the second signal level bears the same predetermined relationship to the first signal level for each frequency or range of frequencies.

25   Additionally illustratively according to this aspect of the invention, the instrument permits the establishment of a first signal level for each frequency or range of frequencies.

Illustratively according to this aspect of the invention, the instrument permits the establishment of the same first signal level for each frequency or range of

30   frequencies.

Further illustratively according to this aspect of the invention, the instrument adapted for dividing the bandwidth of the network into multiple

frequencies or ranges of frequencies and determining the second signal level in each

frequency or range of frequencies is an instrument adapted for fast Fourier

transforming the second signal.

        Additionally illustratively according to this aspect of the invention, the

5     instrument includes a display for providing a graphical representation of the recorded

second signal levels.


## Brief Description of the Drawings

        The invention may best be understood by referring to the following

10    detailed description and the accompanying drawings which illustrate the invention.  In

the drawings:

        Fig. 1 illustrates an algorithm which was developed to test the

invention; and,

        Fig. 2 illustrates an instrument according to the invention incorporated

15    into a specific type of network, namely, a CATV system having a headend and

subscriber terminals including television receivers.


## Detailed Descriptions of Illustrative Embodiments

        An operating mode of an instrument 10 such as, for example, the

20    model 9580 SST available from Trilithic, Inc., 9202 East 33rd Street, Indianapolis,

Indiana 46236, permits the instrument 10 to operate in its normal "short-time peak"

mode, but ignore the energy at each frequency if it is greater than some selectively

variable value.  Of course, the same value can be used for all frequencies in the return

spectrum. However, in other implementations of the invention, different, selectively

25    variable values can be provided for different frequencies or ranges, or bins, of

frequencies.  The disclosure of the Trilithic model 9580 SST is hereby incorporated

herein by reference.  When monitoring upstream traffic, the instrument 10 usually

encounters at least one incidence per 0.7 seconds in each in-use frequency when no

upstream traffic is present.  If the instrument 10 is adjusted, either by some hardware

30    setting or by some software command, to ignore the energy at each frequency if it is

greater than some selectively variable value, sometimes referred to hereinafter as the

traffic floor, traffic threshold or traffic level, corresponding to traffic at that

-5-

frequency, then at the end of each such 0.7 second cycle the resulting spectrum contains only the peak energy at each frequency that does not represent traffic. This is either ingress or, if no ingress is present, baseline noise. If traffic is always present during the cycle, that is, if all the energy at a frequency is greater that the selectively

5      variable value corresponding to traffic at that frequency, the value recorded by the instrument 10 for that cycle is the instrument 10's own baseline noise.

This ingress or baseline noise data capture is selectable by commands in the instrument 10's own ingress management software. Further, since the operator also needs to capture a "raw," unedited spectrum at intervals for archival purposes, the

10     instrument 10 is switched into and out of this data capture without significant delays. This can be done, for example, by providing a real not-to-exceed limit when raw, unedited spectrum capture is desired, and an artificially high value when raw, unedited spectrum capture is not.

If it is assumed that traffic such as digitally modulated signals used for

15     reverse path cable modems 12 occurs in bursts, then it is possible to sample the channel at a time when the traffic within a specified bandwidth is quiet and plot the spectrum of the noise and ingress that appears in that bandwidth. To detect when traffic is absent from the return band spectrum, the instrument 10 either needs a trigger that activates when traffic is absent, or the spectrum must be analyzed and a

20     determination made whether traffic existed during a given sampling interval.

In order to analyze a return band spectrum, the instrument 10 digitally samples the channel and then fast Fourier transforms (FFTs) the sampled data. The FFT has the effect of dividing the energy of the channel into discrete frequency bins, each containing a representation of the energy from the input signal that is present in

25     that bin. The frequency bin spacing is defined as the sampling frequency, $f_s$, divided by the length N of the FFT. An illustrative instrument 10 samples at a rate of 48 MHZ and performs 128 point FFT. There are 375 KHz (48 MHZ/128) of energy content information in each bin. The centers of the various frequency bins are at 0 Hz, 375 KHz, 750 KHz, . . . $f_s$ /2. A digital signal with a bandwidth of 200 KHz thus

30     can have all of its energy appear in one frequency bin, while a digital signal having a bandwidth of 1 MHZ must have at least three bins to accommodate all of its energy.

It should be noted that if the center frequency of a signal appears near a boundary of a frequency bin, that signal's energy may be split between at least two bins.

A traffic curve is entered by the user into the instrument 10 from, for example, a PC 14 software utility. The traffic curve contains a traffic threshold for

5    each frequency bin the instrument 10 is to calculate. In an illustrative embodiment of the instrument 10, there are 112 frequency bins. Frequency bins that are to be treated "normally" will be set to some predetermined number that indicates the instrument 10 is to treat the bins in some way, which will be characterized here as "normal." For example, certain frequency bins to be treated normally may be designated with the

10    hex code 0x7f00. The instrument 10 determines the edges of a traffic bandwidth by seeking out the bins not marked with the hex code 0x7f00. Different frequency bins can have different traffic thresholds, each completely independent from the others, as long as the edges of each traffic bandwidth are indicated by one bin marked, in the example, with the hex code 0x7f00.

15    Within a traffic bandwidth, the levels in the traffic curve indicate the threshold level that the instrument 10 uses to determine if the band contains traffic or signal that is not traffic. An algorithm in the instrument 10 determines if any frequency bins of a given spectrum within the traffic bandwidth being investigated exceed the threshold established for that traffic bandwidth by the traffic curve. If

20    there are any such bins, levels corresponding to the frequency bins within the traffic bandwidth are not recorded. If no bins within a particular traffic bandwidth exceed the threshold set by the traffic curve, then the level of each frequency bin is compared to the currently stored maximum for that bin. If the new value is greater than the stored value, the stored maximum is updated with the new value. This process

25    continues until it is time for the instrument 10 to display the resulting data on its display 16, at which time the stored maximum is reset and the process is repeated.

What is displayed is a plot of the maximum levels that were found to exist below the traffic curve. With appropriately chosen traffic curve levels, it can be concluded with reasonable accuracy that the levels displayed within a traffic

30    bandwidth do, in fact, represent the noise present in a particular channel without the influence of traffic.

Relationships between the average signal level for signals complying with the DOCSIS specification for cable modems 12, and the percentage of time that at least one frequency bin within the traffic bandwidth will be above the average level have been determined using Matlab simulations. Simulation data calculated to a
5      confidence level of 95% appear in Table 1.

| Modulation Type | Symbol Rate | % of Time at least 1 Bin of Traffic Above Traffic Curve Traffic Level = Level of Traffic Signal | | | | | |
|---|---|---|---|---|---|---|---|
| | Ksymb/sec | Avg | Avg-2dB | Avg-4dB | Avg-6dB | Avg-8dB | Avg-10dB |
| QPSK | 160 | 76.7±2.5 | 91.7±1.6 | 91.7±1.6 | 91.7±1.6 | 91.7±1.6 | 94.4±1.4 |
| QPSK | 320 | 69.9±2.7 | 79.6±2.4 | 85.5±2.1 | 97.9±0.8 | | |
| QPSK | 640 | 87.4±2.0 | >99.9 | | | | |
| QPSK | 1280 | >99.9 | | | | | |
| QPSK | 2560 | >99.9 | | | | | |
| 16 QAM | 160 | 63.5±2.8 | 71.6±2.7 | 79.4±2.4 | 89.5±1.8 | 96.2±1.1 | |
| 16 QAM | 320 | 61.5±2.9 | 73.0±2.6 | 83.2±2.2 | 93.0±1.5 | | |
| 16 QAM | 640 | 74.0±2.6 | 90.5±1.7 | 97.4±0.9 | | | |
| 16 QAM | 1280 | 97.1±1.0 | 99.4±0.5 | | | | |
| 16 QAM | 2560 | 99.8±0.2 | | | | | |

**Table 1. Percentage of Time at Least One Bin of a FFTed Traffic Signal will be Above the Traffic Curve**

Table 1 illustrates that there is a significant percentage of the time that the maximum level of the traffic can be expected to fall below the average signal value. Depending on the particular modulation scheme and symbol rate, it may be necessary to set the traffic level below the average level to reduce the likelihood that traffic is mistaken for noise. The likelihood of this occurring can be further reduced by forcing the PC software in this simulation, which corresponds to the software or firmware of an instrument 10 constructed according to the invention, to alarm only if a certain percentage of measurements is above the permissible noise level. For example, if it is determined that 90% of the time at least one bin of the traffic will be above the traffic curve, the alarm could be set to activate only if 2 out of 10 spectra cross the alarm threshold. This will reduce the probability of alarming on a traffic signal.

Referring now to Fig. 1, an algorithm was developed in order to view the noise floor present within an occupied frequency spectrum. This can be accomplished if the equipment used to sample the frequency spectrum samples during periods of time that the signal source for a channel being sampled is not active. Since

5    a typical cable modem 12's reverse channel is inherently bursty, with frequent periods of inactivity. To use the algorithm, a user defines a traffic curve. The traffic curve represents expected traffic, and is the norm against which received signals will be compared to determine the traffic threshold.

The algorithm divides the received spectrum into user-defined

10   channels or bandwidths. A channel can include any arbitrary, user-defined number of frequency bins. The underlying assumption of the algorithm is that if signal is present within a channel, then the frequency spectrum of that channel will be above the traffic threshold. The algorithm treats any signal received in a defined bandwidth that is greater than the traffic threshold as an active channel. Since the purpose of the

15   measurements is to determine ingress and not whether traffic is present in the channel, the results from channels which the algorithm identifies as active are discarded. However, when the algorithm identifies an inactive channel, power present in the bins of the defined channel is a measure of the ingress and noise in that channel.

The above-mentioned simulation was run using the algorithm

20   illustrated in Fig. 1 in order to characterize the behavior of modulation used in the cable modem 12's reverse channel. This simulation revealed that for the algorithm to assess with reasonable accuracy the presence of ingress and noise in the reverse channel, the traffic threshold must be set a few dB below the average level of the signal. Table 1 illustrates the number of dB below the average power level that the

25   traffic threshold was set in the algorithm for different modulation types and rates.

| Variables | Description |
|---|---|
| Buff_TrafficCurve | 128 point buffer that holds the traffic threshold for each frequency bin. 0x7f00 indicates that this bin is to be max compared. LSB indicates which bandwidth this bin belongs to. MSB contains level in dB for traffic threshold. |
| Ptr_TrafficCurve | points to the next traffic threshold location in memory |
| Cntr_CurrentTrafficBins | counts the number of bins in the current traffic bandwidth |
| Cntr_PrevTrafficBins | counts number of bins in the previous traffic bandwidth |
| Thresh_PrevBW | this variable is set to 1 if previous bandwidth exceeded the noise threshold, and is set to 0 if not |
| Thresh_CurrentBW | this variable is set to 1 if the current bandwidth has broken the noise threshold, and is set to 0 if not |
| Buff_TrafficStore | serves as temporary storage for bins within current and previous bandwidths. It is used if no bins in previous or current bandwidth break threshold. Otherwise, it is discarded. The buffer is split into separate sections for current and previous bandwidth. |
| Ptr_CurrentTrafficStore | points to next location in Buff_TrafficStore to store the current bin temporarily. |
| PtrBeg_CurrentTrafficStore | points to the beginning of the current bandwidth traffic store. This variable is toggled between previous and current |
| PtrBeg_PrevTrafficStore | points to beginning of the previous bandwidth traffic store. This variable is toggled between the previous and current traffic stores |

**Table 2. Variables Appearing in an Illustrative Algorithm**

In the algorithm, at 100, the next FFT bin is first loaded into memory. Next, that bin's traffic threshold is loaded. If the traffic threshold does not equal the

traffic bandwidth delimiter, 0x7f00 in the example, then at 102 the maximum of the current FFT bin is compared to the previously stored maximum for the bin. If the threshold does equal the traffic threshold delimiter, then at 104 the variable Cntr_CurrentTrafficBin is incremented and, if this bin is the last bin in a return path spectrum, then the variable Thresh_CurrentBW is queried at 106. If Thresh_CurrentBW = 1, the variable Ptr_Output is incremented by Cntr_CurrentTrafficBin, the variable Thresh_CurrentBW is set equal to 0, the variable Thresh_PrevBW is set equal to 0, the variable Cntr_CurrentTrafficBin is set equal to 0, and the variable Cntr_PrevTrafficBin is set equal to 0, all at 108.

If at 106 Thresh_CurrentBW ≠ 1, then at 110 Current Bin is queried to determine if it is greater than or equal to Traffic Threshold. If Current Bin is greater than or equal to Traffic Threshold, then, again at 108, Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0. If at 110 Current Bin is not greater than or equal to Traffic Threshold, then at 112 Thresh_PrevBW is queried to determine if it equals 1. If Thresh_PrevBW = 1, then, again at 108, Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0. If at 112 Thresh_PrevBW ≠ 1, then Cntr_CurrentTrafficBin is set equal to 0, Cntr_PrevTrafficBin is set equal to 0, and Cntr_CurrentTrafficBin and Cntr_PrevTrafficBin are compared to the contents of the FFT bins, all at 114.

If at 104 the bin just loaded is not the last bin in a return path spectrum, then at 116 the next bin's traffic threshold is loaded. If the next bin's traffic threshold does not equal the traffic bandwidth delimiter, 0x7f00 in the example, then Thresh_CurrentBW is queried, again at 106. If Thresh_CurrentBW = 1, Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, again all at 108. If Thresh_CurrentBW ≠ 1, then Current Bin is queried, again at to determine if it is greater than or equal to Traffic Threshold. If Current Bin is greater than or equal to Traffic Threshold, then Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set

equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, again all at 108. If Current Bin is not greater than or equal to Traffic Threshold, then Thresh_PrevBW is queried to determine if it equals 1. If Thresh_PrevBW = 1, then Ptr_Output is incremented by

5      Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, again all at 108. If Thresh_PrevBW ≠ 1, then Cntr_CurrentTrafficBin is set equal to 0, Cntr_PrevTrafficBin is set equal to 0, and Cntr_CurrentTrafficBin and Cntr_PrevTrafficBin are compared to the previously stored maxima in the FFT bins,

10    again all at 114.

Returning to 116, if the next bin's traffic threshold does equal the traffic bandwidth delimiter, 0x7f00 in the example, then the Least Significant Bit of the current bin's traffic threshold is queried at 118. If the LSB of the current bin's traffic threshold equals the LSB of the next bin's traffic threshold,

15    Thresh_CurrentBW is queried at 120. If Thresh_CurrentBW = 1, the current iteration is complete as indicated at 122. If Thresh_CurrentBW ≠ 1, then the current bin is queried at 124. If the current bin is greater than or equal to the traffic threshold, then Thresh_CurrrentBW is set equal to 1 as indicated at 126. If the current bin is not greater than or equal to the traffic threshold, then the current iteration is complete, as

20    indicated at 128.

If at 118 the LSB of the current bin's traffic threshold is not equal to the LSB of the next bin's traffic threshold, then Thresh_CurrentBW is queried at 130. If Thresh_CurrentBW = 1, Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 1,

25    Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, all at 132. If at 130 Thresh_CurrentBW ≠ 1, then the current bin is queried at 134 to determine if it is greater than or equal to the traffic threshold. If the current bin is greater than or equal to the traffic threshold, then Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set

30    equal to 1, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, all at 132.

If at 134 the current bin is not greater than or equal to the traffic threshold, then Thresh_PrevBW is queried at 136. If Thresh_PrevBW equals 1, then Ptr_Output is incremented by Cntr_CurrentTrafficBin, Thresh_CurrentBW is set equal to 0, Thresh_PrevBW is set equal to 0, Cntr_CurrentTrafficBin is set equal to 0, and Cntr_PrevTrafficBin is set equal to 0, all at 138. If Thresh_PrevBW ≠ 1, then Cntr_PrevTrafficBin is compared to the previously stored maxima in the FFT bins, Cntr_PrevTrafficBin is set equal to Cntr_CurrentTrafficBin, and Cntr_CurrentTrafficBin is set equal to 0, all at 140.

CLAIMS:

1.    A method of testing a communication network for ingress including (a) establishing a first signal level corresponding to presence of a communication signal on the network, (b) determining a second, current signal level, (c) comparing the second signal level to the first signal level, and (d) if the second signal level does not bear the predetermined relationship to the first signal level, recording the second signal level.

2.    The method of claim 1 further including repeating steps (b) -- (d).

3.    The method of claim 2 further including dividing a bandwidth of the network into multiple frequencies or bands of frequencies, and repeating steps (b) -- (d).

4.    The method of claim 3 wherein establishing a relationship includes establishing the same relationship for each frequency or band of frequencies.

5.    The method of claim 3 wherein establishing a first signal level includes establishing a first signal level for each frequency or range of frequencies.

6.    The method of claim 5 wherein establishing a relationship includes establishing the same relationship for each frequency or range of frequencies.

7.    The method of claim 5 wherein establishing a first signal level for each frequency or range of frequencies includes establishing the same first signal level for each frequency or range of frequencies.

8.    The method of claim 7 wherein establishing a relationship includes establishing the same relationship for each frequency or range of frequencies.

9.    The method of claim 1 further including dividing a bandwidth of the network into an arbitrary number of frequencies or ranges of frequencies, and repeating the method includes moving to another frequency or range of frequencies and repeating the method.

10.    The method of claim 9 wherein establishing a relationship includes establishing the same relationship for each frequency or range of frequencies.

11.    The method of claim 9 wherein establishing a first signal level includes establishing a first signal level for each frequency or range of frequencies.

12. The method of claim 11 wherein establishing a first signal level for each frequency or range of frequencies includes establishing the same first signal level for each frequency or range of frequencies.

13. The method of claim 12 wherein establishing a relationship

5 includes establishing the same relationship for each frequency or range of frequencies.

14. The method of claim 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or 13 wherein dividing a bandwidth of the network into multiple frequencies or ranges of frequencies and determining the second signal level together include fast Fourier transforming the second signal.

10 15. The method of claim 14 further including providing a graphical representation of the recorded second signal levels.

16. The method of claim 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or 13 further including providing a graphical representation of the recorded second signal levels.

15 17. An instrument for testing a communication network for ingress, the instrument adapted for coupling to the network, the instrument permitting the establishment of a first signal level corresponding to presence of a communication signal on the network, determining a second, current signal level on the network, and comparing the second signal level to the first signal level, the instrument adapted for

20 determining if the second signal level bears a predetermined relationship to the first signal level, and, if the second signal level does not bear the predetermined relationship to the first signal level, recording the second signal level.

18. The instrument according to claim 17 adapted for dividing the bandwidth of the network into multiple frequencies or ranges of frequencies, the

25 instrument permitting the establishment of a first signal level in each frequency or range of frequencies corresponding to the presence of a communication signal in that frequency or range of frequencies, the instrument adapted for then moving to another frequency or range of frequencies and repeating the process.

19. The instrument of claim 18 adapted for determining if the

30 second signal level bears the same predetermined relationship to the first signal level for each frequency or range of frequencies.

20.    The instrument of claim 18 permitting the establishment of a first signal level for each frequency or range of frequencies.

21.    The instrument of claim 20 for permitting the establishment of the same first signal level for each frequency or range of frequencies.

5          22.    The instrument of claim 21 adapted for determining if the second signal level bears the same relationship to the first signal level for each frequency or range of frequencies.
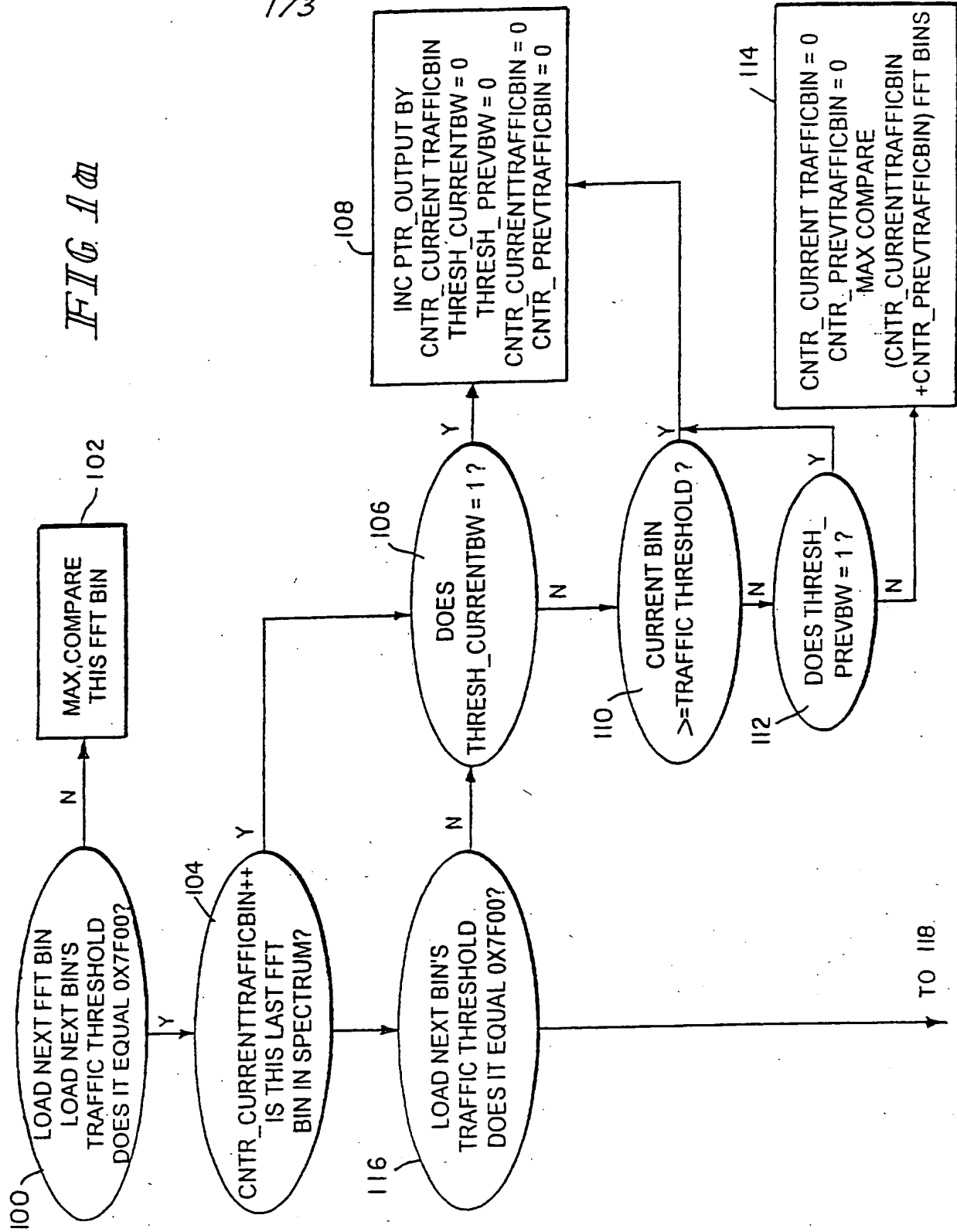
23.    The instrument of claim 18, 19, 20, 21 or 22 adapted for dividing the bandwidth of the network into multiple frequencies or ranges of

10    frequencies and determining the second signal level in each frequency or range of frequencies being an instrument adapted for fast Fourier transforming the second signal.

24.    The instrument of claim 23 including a display for providing a graphical representation of the recorded second signal levels.

15          25.    The instrument of claim 17, 18, 19, 20, 21 or 22 including a display for providing a graphical representation of the recorded second signal levels.

*FIG. 1a*
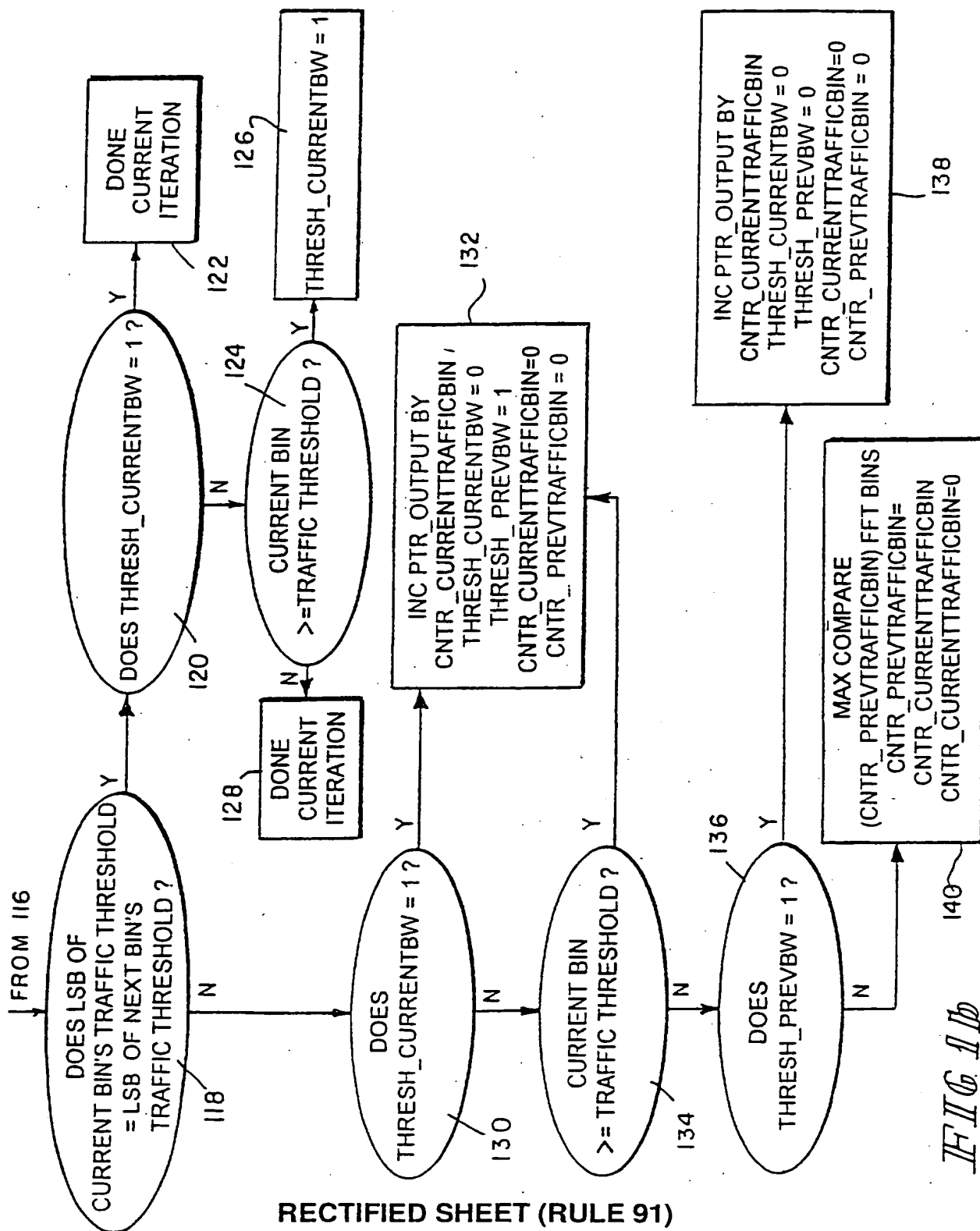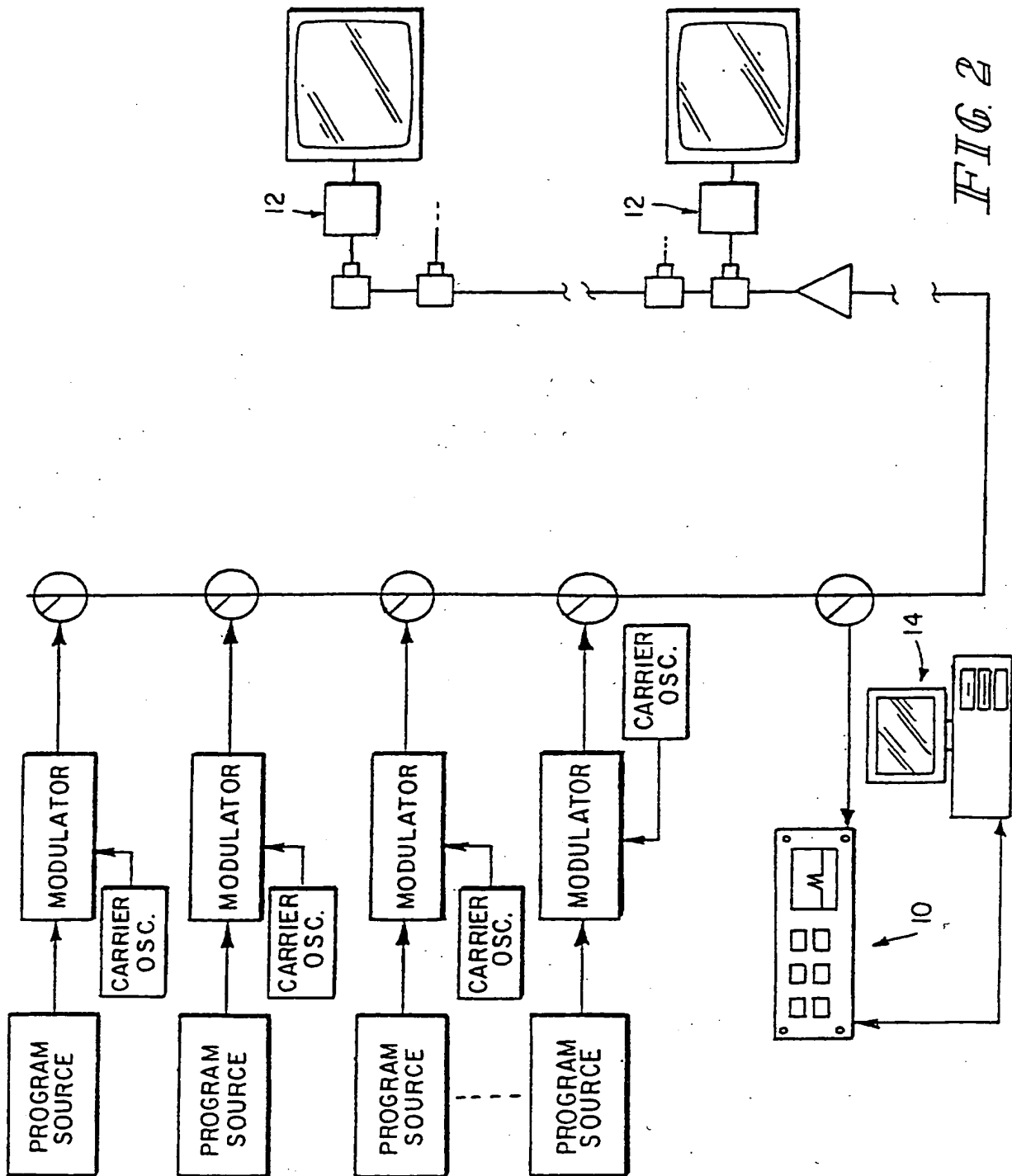
1/3

*FIG. 1b*

**FROM 116**

**118** DOES LSB OF CURRENT BIN'S TRAFFIC THRESHOLD = LSB OF NEXT BIN'S TRAFFIC THRESHOLD ?

**120** DOES THRESH_CURRENTBW = 1 ?

**122** DONE CURRENT ITERATION

**124** CURRENT BIN >= TRAFFIC THRESHOLD ?

**126** THRESH_CURRENTBW = 1

**128** DONE CURRENT ITERATION

**130** DOES THRESH_CURRENTBW = 1 ?

**132** INC PTR_OUTPUT BY CNTR_CURRENTTRAFFICBIN /
THRESH_CURRENTBW = 0
THRESH_PREVBW = 1
CNTR_CURRENTTRAFFICBIN=0
CNTR_PREVTRAFFICBIN = 0

**134** CURRENT BIN >= TRAFFIC THRESHOLD ?

**136** DOES THRESH_PREVBW = 1 ?

**138** INC PTR_OUTPUT BY CNTR_CURRENTTRAFFICBIN
THRESH_CURRENTBW = 0
THRESH_PREVBW = 0
CNTR_CURRENTTRAFFICBIN=0
CNTR_PREVTRAFFICBIN = 0

**140** MAX COMPARE (CNTR_PREVTRAFFICBIN) FFT BINS
CNTR_PREVTRAFFICBIN=
CNTR_CURRENTTRAFFICBIN
CNTR_CURRENTTRAFFICBIN=0

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FIG. 2

# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N17/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5 939 887 A (HARRIS GERALD S ET AL) 17 August 1999 (1999-08-17) <br><br> column 2, line 18 - line 57 <br> column 8, line 45 - line 62 <br> column 4, line 54 - line 67 <br> column 6, line 42 -column 7, line 15 <br> --- | 1-3,9, 10, 14-17,25 |
| A | WO 99 00981 A (TRILITHIC INC) 7 January 1999 (1999-01-07) <br> page 1, line 20 - line 29 <br> page 4, line 13 - line 32 <br> ----- | 1,17 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 8 December 2000 | 15/12/2000 |

| Name and mailing address of the ISA <br> European Patent Office, P.B. 5818 Patentlaan 2 <br> NL – 2280 HV Rijswijk <br> Tel. (+31-70) 340-2040, Tx. 31 651 epo nl. <br> Fax: (+31-70) 340-3016 | Authorized officer <br><br> Beaudoin, O |

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| Patent document cited in search report | | Publication date | Patent family member(s) | | Publication date |
|---|---|---|---|---|---|
| US 5939887 | A | 17-08-1999 | NONE | | |
| WO 9900981 | A | 07-01-1999 | AU | 8153198 A | 19-01-1999 |
| | | | CN | 1267424 T | 20-09-2000 |
| | | | EP | 0992159 A | 12-04-2000 |